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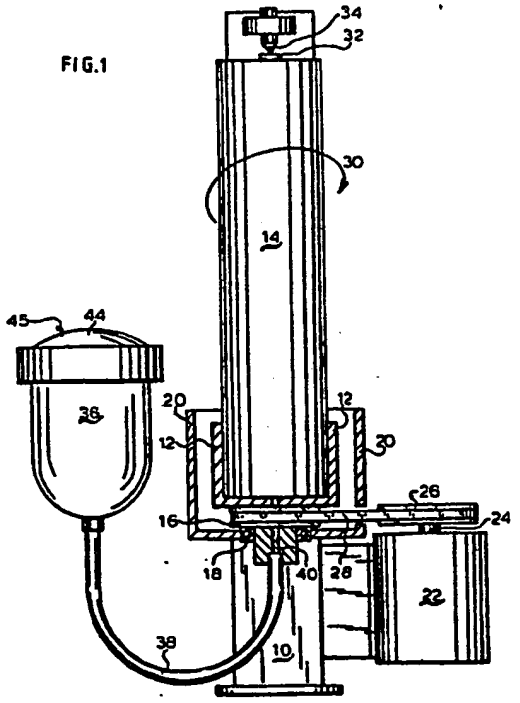
(54) Method and apparatus for impregnating with potting compound the end of a tubular bundle of hollow separatory fibres, and a fibre bundle impregnated by the method.

(57) The lower end of a tubular bundle 14' of fibres is impregnated with a potting compound by a centrifugal technique in which the bundle 14 has its bottom end supported in a mould 12 which is rotated by a motor 22 through a belt drive 26, 28, 16. While the mould 12 and the bundle 14 are being rotated, potting compound is supplied from a reservoir 36 through a hose 38 and a duct 40 to the bottom of the bore of the bundle 14 within the mould 12. Centrifugal force causes the potting compound to flow outwards through the bundle until it fills the mould 12. The centrifugal force displaces air bubbles held between the fibres and ensures complete encapsulation of the fibres. When the mould 12 is full, spinning and the supply of potting compound is stopped and the end of the bundle 14 is left in the mould 12 until the potting compound has reached a desired state of cure.

FIG.1



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Method and apparatus for impregnating with potting compound the end of a tubular bundle of hollow separatory fibres, and a fibre bundle impregnated by the method.

The use of membranes to effect separation of gas/gas, liquid/liquid, and liquid/solid mixtures and solutions has achieved general industrial applicability by various methods, among them being ultrafiltration, hyperfiltration, reverse osmosis and dialysis. In general, membranes used in these methods are contained in vessels called modules which comprise a container having various inlet and outlet ports and an assembly of membranes within the container. The internal arrangements of the modules are such as to permit the introduction of a feed stream either under pressure or not on the upstream faces of the membranes and means are provided for collecting permeate which passes through the membranes and emerges on their downstream faces. Means are also, of course, provided for keeping the feed stream and the permeate from commingling.

Membranes have been fabricated in various shapes, such as (1) flat sheets which may be supported in a plate and frame structure similar to a filter press; (2) initially flat sheets which are rolled into spirals with spacing materials interleaved with the membrane and the assembly being sealed to provide spiroidal channels permitting the passage of a feed on one side of the rolled membrane through spaces to the opposite side of the membrane; (3) tubes which line the inner surface of a reinforced braid, the braid itself sometimes being a component in a larger tube; and (4) in the form of open-ended

hollow fibres so arranged and sealed into header plates as to provide a separation of the flow over the external surfaces of the hollow fibres from flows within the bores of the hollow-fibres which ensue by virtue of the passage of permeant through the membranes which forms the walls of the hollow fibres.

Of particular interest is the use of hollow fibres assembled in a modular form to provide the desired separation.

In our European Patent Application No. 79301885.4 which was published on 2nd April 1980 (Publication No. 0,009,374), various techniques for the selection and winding of hollow fibres and the fabrication and assembly of such fibres into modular form are described. It is noted that a significant consideration in this work is the manner and means of terminating the hollow tubular bundle of fibres so that the ends of the fibres can be opened to allow for the recovery of the permeate from within the hollow fibres and at the same time provide suitable support for the fibres to resist the thrust forces developed by the internal pressures within the module in which the fibres are contained. In the above Applications, the use of potting compound solidified around the ends of the fibres is described and slices are taken through the potting compound to expose the fibre bores while providing adequate support to resist internal pressure. The provision of recesses of suitable configuration and position in the potting compound within which the fibre ends are disposed is illustrated.

It has been found however that in order to achieve satisfactory termination of the fibres it is necessary that the end of the hollow tubular bundle of fibres at which the slices are to be taken must be thoroughly impregnated with potting compound in a substantially uniform manner and mere immersion of the end of the bundle in potting compound or spraying of the end of the bundle with potting compound will not achieve uniform void free potting and encapsulation of all of the fibres.

The inventors of the present invention have now devised a method of impregnating the end of a hollow tubular bundle of fibres with potting compound which produces a very satisfactory result. They have also devised an apparatus for carrying out the method.

Thus according to one aspect of the present invention, we provide a method of impregnating the end of a hollow tubular bundle of fibres with potting compound, the method comprising mounting the end of the bundle within a mould and spinning the bundle at a controlled speed about an upright axis which extends along the bore of the tubular bundle while supplying potting compound to the bore within the mould, whereby centrifugal force developed by the spinning operation causes the compound to flow radially outwardly to encapsulate the fibres in the end of the bundle within the mould, and then stopping the spinning and allowing the end of the bundle to remain in the mould until a desired cure of the potting compound is reached.

The invention also consists, according to another of its aspects, in apparatus for carrying out the method in accordance with the invention, the apparatus comprising a base, a bundle potting mould constructed to receive the end of the fibre bundle,

support means for supporting the fibre bundle in the mould, potting compound injection means for injecting potting compound into the bore of the fibre bundle within the mould, control means for controlling the rate at which the potting compound is injected into the bore of the fibre bundle, and rotation means for rotating the mould and the fibre bundle about an upright axis on the base, whereby potting compound in the bore of the fibre bundle is caused to move outwardly into the end of the bundle under the influence of centrifugal force.

The invention also consists in a hollow tubular bundle of fibres having one end impregnated with potting compound by the method in accordance with the invention.

An example of a method and of apparatus in accordance with the invention will now be described with reference to the accompanying drawings in which:-

Figure 1 is a partly sectional side view of the apparatus with a bundle of fibres ready for impregnation thereon;

Figure 2 is a partially sectional detail of part of the apparatus to a larger scale illustrating the build up of potting compound during impregnation; and,

Figure 3 is a sectional plan view in the direction of the arrows on the line 3-3 in Figure 2.

As shown in the drawings, the apparatus comprises a base 10, a bundle potting mould 12, in which the lower end of a hollow tubular bundle of fibres 14 is, in use, supported, a pulley 16 and a bearing 18 allowing for rotation of the mould 12 and the bundle 14 relative to the base. The base 10 also supports a cylindrical shield 20, which is concentric with the mould 12 and is spaced therefrom, and a variable speed electric motor 22, a shaft 24 of which

drives a pulley 26, which in turn rotates the pulley 16 and the mould 12 by means of a drive belt 28.

When the motor 22 is energized, the bundle 14 is rotated with the mould 12 about its axis in the direction of an arrow 30. A rigid shaft 32 within the bundle 14, and bearing 34 support the upper end of the bundle during rotation. If the bundle 14 is sufficiently rigid and self-supporting the shaft 32 may not be necessary and a cap or plug member can be used to support the top of the bundle 14 from the bearing 34 in the illustrated example of the apparatus. However it should be understood that the bearing 34 is shown as an example only and other suitable means for maintaining the position of the bundle may be utilized.

A reservoir 36 is supported adjacent the base 10 and is connected by means of a hose 38 to a conduit 40 which allows for passage of potting compound, for example epoxy resin, from the reservoir into the bore 42 (see Figure 2) of the bundle 14 up to a desired height. Pressure is applied in the upper part 44 of the reservoir 36 by means of a gas inlet 45 to force resin into the mould 12. The shield 20 is provided for protection against any potting compound which might be thrown centrifugally out of the mould 12 during impregnation.

In operation, the motor 22 is energized and the mould 12 and the bundle 14 are rotated about their upright axes as resin is fed through the conduit 40 and into the bore 42 of the bundle 14. The bundle is spun about the upright axis and the potting compound is spun radially outwardly by centrifugal force. If it is found necessary to ensure void-free impregnation, the speed of rotation of the mould 12 may be changed during impregnation. As the potting

compound moves outwardly, it displaces air in the interstices between the fibres and fills the mould. As the potting compound appears to leave the top of the mould, spinning is stopped and the bundle is allowed to sit in the mould until the desired cure of the potting compound is reached. After spinning has stopped, the mould and the fibre bundle can be removed from the base, thus allowing a new mould and fibre bundle to be installed and impregnated before the previous potting compound has reached the desired cure.

Typical examples for 50 mm and 75 mm external diameter bundles of 0.25 mm external diameter hollow fibres are:

Potting compound: 25% talc filled bis-phenol-A epoxy resin cured with a mixed amine:

	50 mm dia. bundle.	75 mm dia bundle.
Initial resin viscosity	7500 centipoises	7500 centipoises
Pressure on potting compound	31 kN/m^2	31 kN/m^2
Rotation Speed	650 rpm	760 rpm
Time to fill mould	10-20 min.	15-20 min.
Initial Resin Temperature	25°-30°C	25°-30°C

Potting compound: Unfilled bisphenol-A epoxy resin cured with a polyamido-amine.

	50 mm dia. bundle.	75 mm dia. bundle
Initial resin viscosity	5200 centipoises	5200 centipoises
Pressure on compound	31 kN/m^2	31 kN/m^2
Rotation Speed	450 rpm	450 rpm for 2 min; 900 rpm until filled

	50 mm. dia. bundle.	75mm dia. bundle.
Time to fill mould	10-20 min.	10-20 min.
Initial Temperature	25°C-30°C	25°-30°C

Urethanes and other resins can alternatively be used as potting compounds. The time to fill the mould depends upon many variables including viscosity, cure rate, temperature, rotation speed, fibre diameter, fibre density in the bundle and thickness of the wall of the bundle. Exact operating conditions are determined experimentally.

The utilization of a rigid bundle allows the method to be used and the method forces air bubbles out of the bundle. This method provides uniform potting or impregnation in contrast to methods where the bundle end is infused with potting compound under the influence of gravity or vibratory energy only.

CLAIMS

1. A method of impregnating the end of a hollow tubular bundle of fibres with potting compound, the method comprising mounting the end of the bundle within a mould and spinning the bundle at a controlled speed about an upright axis which extends along the bore of the tubular bundle while supplying potting compound to the bore within the mould, whereby centrifugal force developed by the spinning operation causes the compound to flow radially outwardly to encapsulate the fibres in the end of the bundle within the mould, and then stopping the spinning and allowing the end of the bundle to remain in the mould until a desired cure of the potting compound is reached.

2. A method according to Claim 1, in which the the potting compound is supplied under pressure to the bore.

3. A method according to Claim 1 or Claim 2, in which the spinning time is determined in dependence upon viscosity, cure rate and temperature of the potting compound, and upon speed of rotation, fibre diameter and fibre density in the bundle.

4. A method according to any one of Claims 1 to 3, in which the mould and the bundle are removed from the spinning apparatus after spinning while curing of the potting compound takes place.

5. Apparatus for carrying out the method in accordance with Claim 1, the apparatus comprising a base (10), a bundle potting mould (12) constructed to receive the end of the fibre bundle (14), support means (34) for supporting the fibre bundle in the mould (12), potting compound injection means (36, 38, 40) for injecting potting compound into the bore (42) of the fibre bundle (14) within the mould 12, control means for controlling the rate at which the potting compound is injected into the bore (42) of the fibre bundle (14),

and rotation means (14, 28, 26, 22) for rotating the mould (12) and the fibre bundle (14) about an upright axis on the base, whereby potting compound in the bore (42) of the fibre bundle 14 is caused to move outwardly into the end of the bundle (14) under the influence of centrifugal force.

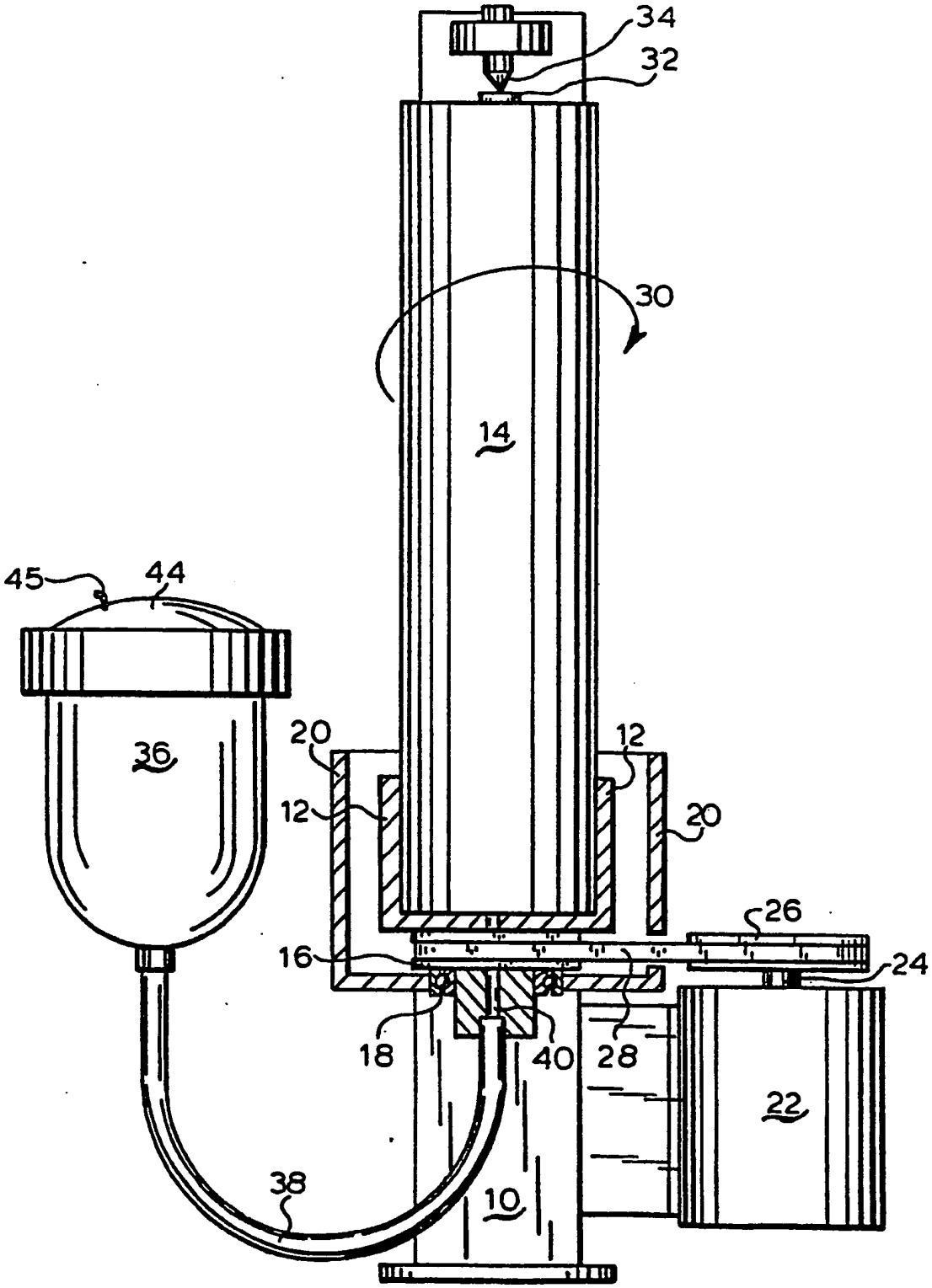
6. Apparatus according to Claim 5, in which the injection means includes a reservoir (36) and conduit means (38, 40) connecting the reservoir (36) to the bore (42) of the fibre bundle (14) and the control means includes pressure means (45) for applying pressure to the potting compound in the reservoir (36).

7. Apparatus according to Claim 5 or Claim 6, in which the supporting means includes a rigid shaft (32) within the bore (42) of the fibre bundle (14) and an upper bearing support (34) engaged therewith.

8. Apparatus according to Claim 5 or Claim 6, for impregnating a rigid bundle of fibres, in which the supporting means includes an upper bearing support (34) engaged directly with the top of the bundle (14).

9. A hollow tubular bundle of fibres having one end impregnated with potting compound by a method in accordance with any one of Claims 1 to 4.

FIG.1



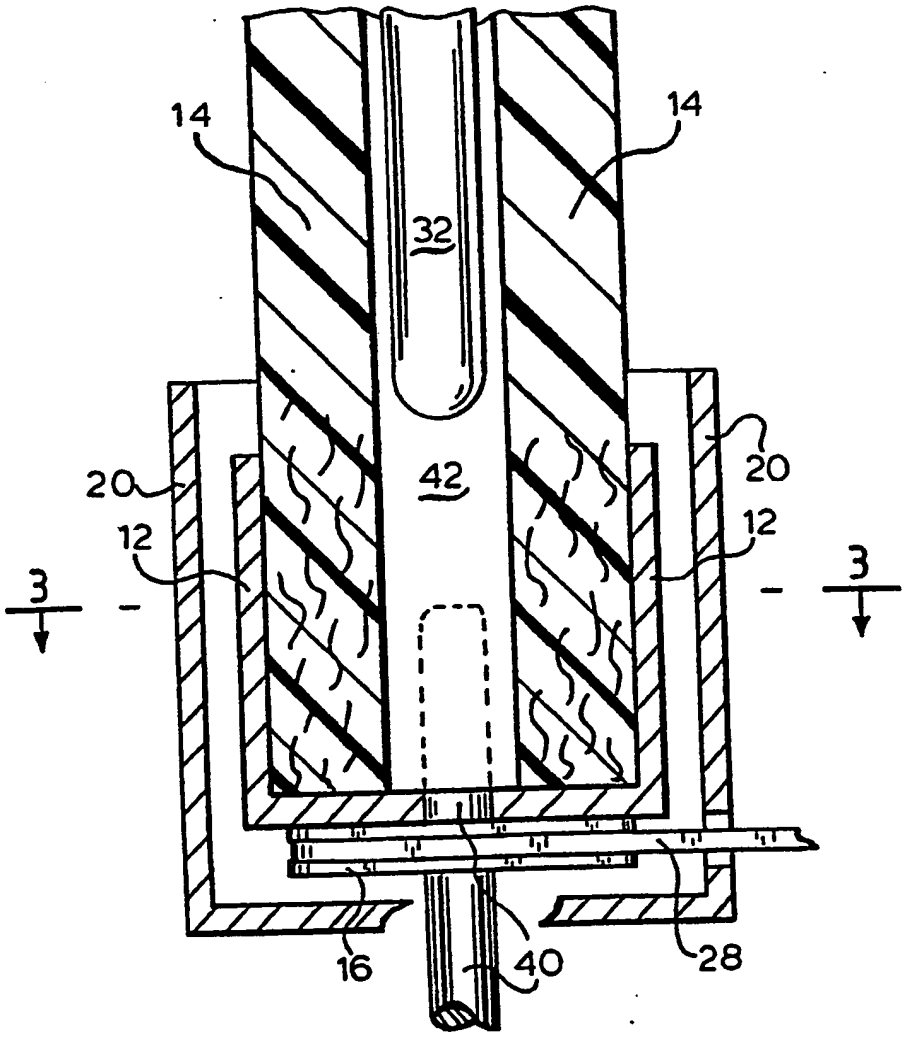


FIG.2

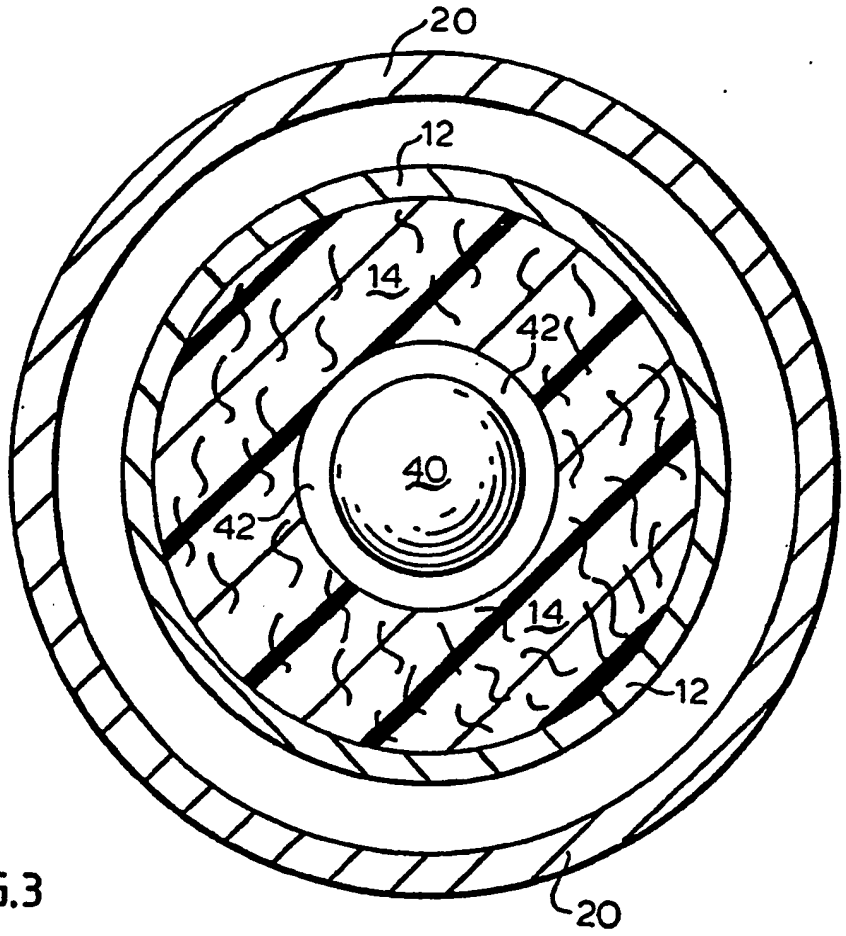


FIG.3

European Patent Office

EUROPEAN SEARCH REPORT

0046015
Application number
EP 81 30 3230

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim
X	US - A - 4 179 380 (C. AMICEL) * Figures 9,10; column 11, line 46 to column 12, line 27 *	1,2,4-6,9
A	FR - A - 2 309 263 (NIPPON ZEON Co. Ltd.) & US - A - 4 049 765 & US - A - 4 105 731	
A	GB - A - 1 380 393 (I.C.I. LTD.)	
A	US - A - 3 492 698 (J.E. GEARY Jr)	
A	FR - A - 2 344 262 (ORGANON TEKNIKA B.V.) & US - A - 4 219 426	
A	FR - A - 2 358 910 (BENTLEY LABORATORIES INC.) & GB - A - 1 589 734 & GB - A - 1 589 735	

CLASSIFICATION OF THE APPLICATION (Int. Cl.³)

B 01 D 13/00
31/00
B 29 C 5/04

TECHNICAL FIELDS SEARCHED (Int. Cl.³)

B 01 D 13/00
31/00
53/22
B 29 C 5/04
C 02 F 1/44
A 61 M 1/03
F 28 F 21/06

CATEGORY OF CITED DOCUMENTS

X: particularly relevant
A: technological background
O: non-written disclosure
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T: theory or principle underlying the invention
E: conflicting application
D: document cited in the application
L: citation for other reasons

&: member of the same patent family, corresponding document

X The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	27.08.1981	HOORNAERT

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